[15] A very important conclusion he reached was that the primary advantage of interlace was a reduction in the visibility of line structure (he compared 625 lines interlaced with 312.5 lines progressive) but that both systems could render about the same spatiotemporal spectrum of video information.

Unfortunately, nearly everyone involved in the discussion is an employee of a company with a vested interest in the outcome. For example, the Japanese evidently still hope that 1125/60 will be the
.ul
de facto
production standard, so that their existing lines of equipment will dominate the professional market from the start. The computer companies' interests are likewise obvious. They are interested mainly in interoperability.

In the ATTC tests, the two interlaced systems had slightly higher subjective quality than the two progressive systems, except on a computer-generated sequence in which the scores were reversed. The progressive proponents claim that the trouble was that the progressive camera that they used was inferior to the Sony interlaced camera, which may well be true.

Involving as it does perceptual considerations, camera and display technology (now and in the future), possible effects on compression ratio, and in the absence of definitive tests, it is very difficult to present an analysis that is both convincing and unbiased. I shall try.

.ul
How Interlace Works

The primary advantages usually associated with interlace (Clarke's conclusions, above, are quite novel) can be thought of from two different points of view. For a given bandwidth, interlace, if it works perfectly, either doubles the vertical resolution or it doubles the large-area flicker rate, depending on the scan parameters. In fact, in neither of these effects does it work very well except at very low display brightness. Long ago, Brown [16] found that these
hoped-for factors of 2 depended on brightness and were only about 1.1 at typical display brightness. In addition, interlaced displays are subject to interline flicker and produce quite noticeable aliasing in the presence of movement. Why then has interlace been used for so long? Why has it been abandoned for computer displays?

Interline flicker is not very troublesome in today's TV primarily because interlaced cameras, both tube and solid state, have very poor vertical resolution due to the fact that the integration time per sample is one field time and not one frame time.**
.(f
**This ''defect'' of interlaced cameras actually is essential to make the pictures at all acceptable. If the integration time at each sample point were one full frame rather than one field, then objects in horizontal motion would show serrated vertical edges.
.)f
Thus the light input to two adjacent scan lines in the frame
is averaged in the camera,
causing vertical blur. If the video information actually has full vertical resolution as limited only by the number of lines/frame, then interline flicker occurs in all detailed areas of the image. The scan lines do not have to be resolved either by the eye or the CRT for this flicker to be visible.
As long as the
.ul
horizontal
extent of the detail on adjacent lines is both visible and different, interline flicker occurs at the frame rate. Typical pictures from a laser scanner, for example, flicker unacceptably when displayed on an interlaced monitor. An extreme example is a picture with alternate black and white lines.
.ul
The vast majority of TV people have never seen this effect.
During a period when my MIT laboratory had a Sony contract, I showed this to dozens of Sony engineers
using laser-scanned images.
None of them had seen the effect previously. They
generally thought that there was something wrong with the monitor. We later had an even more convincing demonstration
using a laser-scanned image of a dollar
bill, displayed on both interlaced and noninterlaced
monitors. We showed it to hundreds of
visitors, and it was a surprise to every one, without exception.

Another flaw in much of the analysis is the assumption that the vertical resolution of a camera depends primarily on the beam diameter and is independent of the scan format. [17] The equilibrium discharge of
a camera target is a nonlinear process; the effective spot size and shape depend on the local image intensity and the corresponding amount of charge. Except at very high brightness, as the beam moves down the camera target, discharge is primarily effected by the leading and lower edges of the beam. A given camera typically has substantially higher vertical resolution with progressive scanning than it has with interlace. The limiting vertical frequency response, (which can, of course, be less for inferior tubes) for images of full dynamic range, is simply the number of scan lines per
.ul
field.
This reduces the resolution when interlace is used, and this is why we see little interline flicker in NTSC and PAL.

A point often made by interlace enthusiasts is that progressive displays are only better because they have twice the bandwidth. They also state that a progressive camera with the same resolution as an interlaced camera is much less sensitive because the extra bandwidth results in more noise.
By resolution, they mean the number of samples/frame, the progressive camera having twice the bandwidth because it has double the frame rate.

Of course, cameras must be compared at the same bandwidth. I believe that the proper comparison would be between two cameras with the same number of scan lines/frame and the same vertical scan frequency. The progressive camera would use quincunx sampling preceded by a diamond-shaped spatial filter, so that both signals would have the same sample rate and bandwidth. (The interlaced signal could be derived from the same camera if alternate lines on alternate fields were discarded after processing by a diamond-shaped vertical-temporal filter. This would reduce the vertical-temporal aliasing commonly seen today.) The sensitivities would now be much closer. Recall that the fundamental limitation on camera sensitivity is the number of photons per picture element. Two systems that use different scan patterns but have the same picture-element rate have the same limiting sensitivity.

I think it reasonable to assume that, in the future, cameras will improve with respect to vertical resolution. There certainly will be much more use of computer-generated imagery, which does not have the limitations caused by camera physics. In view of the better interoperability of progressively scanned systems and because of the absence of the interlace artifacts referred to above, I think progressive scan is the clear choice for future systems.

Received: from Kodak.COM (kodakr.kodak.com) by mailroom.itc.kodak.com with SMTP id AA148(
 (5.65c/IDA-1.4.4); Sun, 17 Oct 1993 16:05:53 -0400
Received: from FARNSWORTH.MIT.EDU by Kodak.COM (5.61+/2.1-Eastman Kodak)
 id AA06202; Sun, 17 Oct 93 16:07:45 -0400
Received: by farnsworth.mit.edu (5.57/Ultrix3.0-C)
 id AA02049; Sun, 17 Oct 93 16:04:42 -0400
Received: by image.mit.edu (4.1/SMI-4.0)
 id AA18583; Sun, 17 Oct 93 16:04:02 EDT
Date: Sun, 17 Oct 93 16:04:02 EDT
From: wfs@image.mit.edu (William Schreiber)
Message-Id: <9310172004.AA18583@image.mit.edu>
To: hierarchy%farnsworth@kodakr.kodak.com
Subject: Error in the EC paper
Cc: dmanning@image.mit.edu, wfs@image.mit.edu
Status: R

For those of you who received a copy of my EC report, please not the following:
ecerror

Correction of an error in my EC report

Zenith has called my attention to an error in describing their VSB channel-coding system. On page 40, the last paragraph in the section "The Terrestrial Channel" should read as follows:

"Three of the systems, as tested, used quadrature amplitude modulation (QAM) while the ATT/Zenith system used vestigial-sideband modulation and employed a pilot carrier at the edge of the band to facilitate synchronization at the receiver. The QAM systems used trellis coding and Reed-Solomon FEC, while the VSB system used Reed-Solomon FEC only. Systems under consideration by the Alliance include 4-VSB (4 levels), 6-VSB (6 levels with trellis coding), ...(the rest of the paragraph is unchanged.)"

In view of the above, the phrase "rather peculiar" in the last line of Section 4 on page 21 should be eliminated.

Another correspondent has challenged my statement on page 24 that adoption of the Alliance system as MPEG2 (or vice versa) would require giving up possible royalties by GA members on the source-coding algorithm. He pointed out that ISO only requires that royalties that must be paid to practice an ISO standard be reasonable. That may well be true. Considering the immense effort put into MPEG by many groups, I seriously doubt whether MPEG itself would welcome a last-minute switch that requires payment of royalties to GA members.

Received: from Kodak.COM (kodakr.kodak.com) by mailroom.itc.kodak.com with SMTP id AA12407 (5.65c/IDA-1.4.4 for <robertsa@itc.Kodak.COM>); Sat, 16 Oct 1993 14:51:16 -0400
Received: from nps.navy.mil by Kodak.COM (5.61+/2.1-Eastman Kodak) id AA28947; Sat, 16 Oct 93 14:52:56 -0400
Received: from budden.as.nps.navy.mil by nps.navy.mil (4.1/SMI-4.1) id AA15664; Sat, 16 Oct 93 11:43:44 PDT
Message-Id: <9310161843.AA15664@nps.navy.mil>
To: gerovac@rdvax.enet.dec.com, mnl@apple.nosc.mil, robertsa@itc.kodak.com
Cc: hierarchy@farnsworth.mit.edu, inter@farnsworth.mit.edu
Subject: Interoperability of next generation television with networks
Date: Sat, 16 Oct 1993 11:51:29 -0700
From: Rex Buddenberg <budden@budden.nps.navy.mil>
Status: R

To: Robert Sanderson, Kodak, Chair of FCC ATV Interoperability Review Board,
Mike Liebhold, Apple Computer, Vice Chair
Branko Gerovac, Digital Equipment Corporation, Secretary

Subject: Interoperability of next generation television with networks

I have been asked to look at the Grand Alliance proposal with a view to network interoperability. My comments in this letter address this respect.

I have seen some of the discussion regarding issues like display format, display frame rate, interlace versus progressive scan, etc. I do not intend to comment on these issues except to note that the discussion seems to miss some central issues of interoperability outside the exclusive entertainment television domain.

I find the proposals silent on two fundamental points that will seriously inhibit interoperability if they are not addressed. These two points are:

1. Non-support for interactivity.
2. Inability to share the media.

Why are these two points important?

1. Entertainment broadcast is only one use of television (or multi-media). To be successful, the same standards must be used in, for example, videoconferencing and groupware. This is an application that demands video, voice and data transfer operations.

2. In the future, what we today call television, telephone and network services should be delivered to the home by a single 'local loop' -- we cannot afford the wasteful duplication of infrastructure development that non-interoperability would require.

The present proposals, as shown to me, appear to be written solely from the point of view of television broadcasting in the VHF and UHF bands which has historically been an environment where the broadcaster has sole transmit use of his frequency assignment in a licensed area. This assumption is highly questionable in the future:

1. Traditional terrestrial broadcast has been joined by cable and satellite delivery. Both of these media have high potentials for interactivity and indeed are used interactively now in at least some situations.

2. Many networking developments are underway today that will allow multi-media (integrated video, audio and data) in networking environments that are inherently interactive. (MBONE on the Internet is an example). A few of these developments include:

a. Development of Asynchronous Transfer Mode (ATM) as a cell switching technology and standard for wide area networking (and possibly local area networking) that is capable of meeting the deterministic delivery requirements for full motion data streams such as audio and video. Indeed, one of the five ATM Application Layers has specifically been set aside for delivery of the variable bit rate data that compressed video represents.

b. Development of Fiber Data Distributed Interface (FDDI) as a local area networking technology and standard that allows bandwidth reservations (synchronous service) suitable for full motion audio and video delivery.

c. Development of protocols such as eXpress Transfer Protocol (XTP), a next-generation transfer layer (Transport + Network layers) protocol suitable for various quality of service requirements. Examples of these are:

i. Electronic messages and file transfers where reliable delivery is needed and the deterministic characteristics that attend full motion are traded off to gain error protection.

ii. Telemetry applications where data is rapidly refreshed; recovery of errored messages is unwarranted as the data is quickly refreshed.

iii. Entertainment video applications which resemble the telemetry problem.

iv. High precision imagery where latency is not an issue but quality is. Similar to i. above.

v. Teleconferencing where the total network capacity is limited and must be allocated across the video, audio and underlying data support requirements on a dynamic basis.

d. Extension of the electronic mail protocols to the Multi-media Internet Mail Extensions (MIME) standard that permits multiple data content types to be included in e-mail messages. These content types explicitly include audio and video.

e. A variety of commercial applications, commonly known as groupware, that combine various forms of media to support collaborative efforts by remotely located people.

I fail to find any accomodation or even the ability to accomodate any of these technologies within the proposed standards.

All of the examples noted above can easily be included under the rubric of National Information Infrastructure. Indeed, the Internet has been considered part ever since the term was coined. The logical follow-on thought is that the advanced digital television standards development should advance, complement, and leverage these layered architecture standards rather than duplicate and reinvent them.

What is wrong with the Grand Alliance proposals?

The Grand Alliance Interoperability Overview briefing contains a slide with four protocol stacks. These protocol stacks illustrate interactivity and shared media shortcomings in terms of protocol function omissions. The third one, titled 'Interactive E&T', looks like this (and mated with the previous slide titled Layered Architecture):

Qhote:

Interactive E&T Model Protocol Stack	PS-WP4 Reference Model Protocol Stack	ISO Reference
Application	Application	
GA Picture Formats	Picture Format	Presentation
Temporal Comp		
Spatial Comp		
GA/MPEG-2 compress	Code	
	Session	
Video Packet	Transport	
Transwitch	Network	
ATM Transport	Link	
B-ISDN/SONET	Modulation	Physical

end quote

Both the 'Interactive E&T' and the 'PS-WP4 Reference Model Protocol' stacks contain errors, mostly of omission, with respect to the ISO Reference Model. These omissions include the protocols necessary to support interactivity and shared media. A pervasive error seems rooted in different definitions for the term 'transport'. The networking community uses the definition of transport as it is stated in the ISO Reference Model: reliable connection establishment and maintenance. The confusion ensues when either GA/MPEG-2 or ATM is tagged with the term 'transport'. In both cases, this is an incorrect use of the term and causes several derivative errors.

--> The most important error occurs when the Session, Transport, and Network functions get omitted from the Interactive E&T stack. The stack should look like this:

Interactive E&T	ISO Reference Model
Application	Application
GA Picture Formats GA/MPEG-2 compress	Presentation
Session protocol	Session
Transport protocol	Transport
Network protocol	Network
ATM Transport	Link
B-ISDN/SONET	Physical

Transport. None of the protocol suites illustrated provides any means to perform the reliable delivery functions described in the Transport layer of the ISO Reference Model. In a wholly non-interactive scheme, this is understandable, but there is no means to control the end-to-end error environment where interactivity does exist in the underlying media.

The GA presentation points to the low bit error rates in physical media (such as the fiber optic cable used in FDDI). This masks the real problem that will appear in ATM switched networks; the more prevalent errors will occur when two cells collide at a Banyan switch node in an ATM switch causing at least one of the cells to be thrown away entirely. (There is a much less consequential error showing on this slide: FDDI operates at 125M baud and 100M bits per second.)

Network. I see no means in any of the proposed protocol stacks to implement multicasting or even unicasting. This is a Network Layer function.

Most importantly, there appears to be no way to concatenate multiple subnets into an internetwork -- a core function of the protocols (such as Internet Protocol) that operate at the Network layer.

Secondarily, if the television industry hopes to have adequate security gained by not delivering programming to non-paying customers, a multicasting (vice broadcasting) capability is needed.

Session. I see no means of negotiating quality of service (QoS) between the application and the underlying communications network. This is a Session Layer function.

Omission of three layers in a protocol stack would not be irretrievably harmful except that the GA briefing later describes a mapping of a 188 byte video payload packet into four ATM cells. This is, in effect, an interface definition between the Presentation and Data link Layers. This generation of a hardwired interface between Presentation Layer functions and Data link Layer protocols excludes any possibility of inserting the Transport and Network protocol data units -- these protocols cannot be added in later. Irretrievable omission of these protocols would preclude implementation of this protocol stack over any portions of the Internet that do implement these protocols -- total lack of interoperability with any existing or planned Internet.

A gratuitous error in the illustration is the description of the ISO Reference Model as a protocol stack. The Reference Model is an abstract description, and layering, of networking functions. There are several protocol suites that have been built using the Reference Model as a pattern.

Recommendations -- I suggest two:

1. Structure the television standards in a layered architecture that is similar to and cognizant of the protocol architecture in the Internet.
2. Test implementations. In particular some testing should be performed over interactive packet-switched networks.

Recommendation 1 in more detail:

Interactive E&T*	ISO Reference Model
Application	Application
GA Picture Formats GA/MPEG-2 compress	Presentation
Session protocol	Session
XTP | TCP or UDP	Transport
XTP | IP	Network
ATM Transport	Link
B-ISDN/SONET	Physical

*picked because it's the one closest to being salvagable.

The protocol stacks should look like the illustration above.

a. Application and Presentation Layers. The payload format for television delivery should be converged and reconciled with the MIME standard (Internet RFC 1341). Failure to do this will not fatally wound interoperability, but it will make integration between virtual terminal television and e-mail television more difficult. True multimedia integration of voice, video and text will be harder to realize.

b. Session Layers. Provision should be made for negotiation of quality of service (QoS) parameters. This negotiation is between the application (or program) and the underlying media. Different applications have different requirements. Similarly, different media and low level protocols have different capabilities. These QoS parameters should not be hard-wired into a standard; doing so inhibits extensibility.

One experimental setup employs Partially Error Controlled Connections (PECC) -- a QoS regime that lays over the transport layer and under the application layer (including compression).

Development of Session Layer protocols may not be mature enough that early television implementations would actually use one. But provision must be made for later insertion as there is a clear need for this functionality.

c. Transport Layers. The Presentation Layer functions (e.g. MPEG-2, JPEG) should have Transport Layer Interfaces vice the existing attempt at a Data link Layer interface. This will restore the ability to include the omitted protocols and will at least preserve the options of interactivity and shared media (even if not implemented or available in some implementations).

d. Network Layer. Unicasting must be supported or you have no interoperability with respect to networks. Multicasting must be considered a necessity with teleconferencing and entertainment applications. Again, multicasting may not be required in an initial implementation, but you need the extensibility to add it later.

e. Data link Layer. There are many other protocols available for use at this, and the Physical, layer. But since all can interface to the Network layer, omission from the illustration is not an error; certainly not an irretrevable one. In other words, if we can make things work with ATM, we can make it work with with the rest.

Internet RFC 1453 by William Chimiak contains a more complete survey of network, transport and session layer issues.

Recommendation 2 in more detail:

The Internet community has been very successful with its policy of advancing protocols to the status of standards only after multiple, demonstrably interoperable, implementations have been built. Your standards-making effort should do the same. Include this, at a minimum, as a measure of effectiveness in the testing:

"The interoperability should be demonstrated by a television data stream being passed over a network that is also passing other data (such as e-mail and file transfers). Each data stream should be identifiable as a discrete Transport layer logical connection."

This measure of effectiveness should demonstrate both operation in an interactive environment and ability to share the medium.

I hope this assessment helps your important work.

Sincerely,

Rex A Buddenberg

Personal background. I work as a consultant in information systems and I teach networking at the postgraduate level. I participated in the SMPTE Task Force on Digital Image Architecture. I have no affiliation with any of the Grand Alliance proponents. The foregoing comments are wholly my own.

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Re: The HDTV Grand Alliance

Dear Mike and Bob:

Please find "The Grand Alliance" enclosed for your consideration for the interoperability task force for the Advisory Committee on Advanced Television.

Sincerely,

Hugh Carter Donahue, Ph.D.

13 October 93

cc: Dr. Lee McKnight

THE GRAND ALLIANCE[1]

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CAST Working File 1993-007
September 1993

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(Copies Available from the Author)

October 18, 1993

To: Robert Sanderson, Kodak, Chair of FCC ATV Interoperability Review Board
& Mike Liebhold, Apple Computer, Vice Chair
cc: Branko Gerovac, Digital Equipment, Secretary
From: Craig J. Birkmaier (PCUBED)
Re: ACATS Interoperability Review

As a participant in the PS/WP4 process, I have been following the current work of the ACATS with great interest. As you are aware, PS/WP4 identified many critical issues to guide ACATS in the selection of an *interoperable* Digital Advanced Television (DATV) system for North America. It is evident that the PS/WP4 report was influential in the choice of system parameters by the Grand Alliance, announced in May of 1993.

In spite of these well intentioned attempts to address the issues of interoperability by the Grand Alliance, serious questions about the design of the GA system have been raised within the ACATS review process and by observers of the process. Many of those who attended the meeting of the Technical Subgroup of the FCC Advisory Committee on Advanced Television Service in Washington, June 30th and July 1st, including myself, were concerned about the failure of the Technical Subgroup to address these issues. As a result the ATV Interoperability Review Board was created.

My name was submitted for participation on this panel, as an expert in the integration of television, computer and communication technologies. As a technology consultant, I work with companies that are integrating these technologies and write about this rapidly evolving field for several television industry publications. I have been told that I was not included in this process because of potential conflicts between the work of the panel and my role with the press, a position which I understand and respect.

Since the panel included many individuals who had not been heard from in previous ACATS and PS/WP4 reviews, I choose not to make a submission to the Interoperability Review Board prior to the meetings October 6th and 7th. I felt it was more important for you to hear from these individuals than to review the positions and reports that I submitted to the PS/WP4 working group.

Because of other commitments, I was not able to attend the October 6th and 7th meetings in Washington. However, I have discussed the proceeding with more than a dozen individuals who were in attendance and I have received a copy of the draft report of the Interoperability Review Panel distributed by the Chairman, October 14th.

In reviewing this draft, it is abundantly clear that the panel was unable to resolve many of the issues it was empowered to investigate. Furthermore, I find it impossible to reconcile many of the "draft" findings of the panel with the testimony that was provided during the meetings and with the information provided to ACATS over the long history of this process.

I have therefore chosen to make this submission to the Interoperability Review Panel, to comment on the draft report, and register in the public record my objections to the current Grand Alliance proposal for DATV in North America.

This submission is divided into three sections:

1. General Comments and Requirements for Interoperability
2. Specific Comments About the Interoperability Review Panel Draft Report
3. Proposals for a DATV Transmission Standard Compatible with the Emerging National Information Infrastructure

Section 1 - General Comments and Requirements for Interoperability

The ATV selection process began almost a decade ago, at a time when the perceived requirements for an advanced television broadcast system were far different than today's realities. A moving target creates a dilemma for everyone involved in the process: how to be fair to those participants who made significant investments to develop systems that comply with the original requirements, while acknowledging the rapidly evolving landscape of digital communications technology.

To resolve this dilemma, a Technical Subgroup was formed with ACATS to review and recommend modifications to the DATV proposal submitted by the Grand Alliance. The Interoperability Review Panel is an extension of this review process. As an observer of this review process, this approach can only be considered to have reached a successful conclusion when the needs of all affected stakeholders in the ATV decision have been heard and an attempt has been made to accommodate their requirements. It is clear from the draft report that this is not yet the case.

Significant objections to the Grand Alliance proposal were raised by many affected stakeholders during the Interoperability Review meetings, yet these positions are not reflected in the report. Instead, the report avoids the resolution of certain issues by stating that the advocates of polarized positions cannot reach consensus. Avoiding the resolution of critical issues at this time can only lead to problems in the future. The Grand Alliance risks the possibility of developing a system that may not be approved by the FCC, or pursuing an approach that may be rendered obsolete by other government initiatives. And the ACATS process is left open to substantial criticism that the needs of all stakeholder communities were not considered, and appropriate modifications made to the proposed ATV system.

A member of the Joint Experts Group on Interoperability, Michael Haley, employs a helpful technique to make participants involved in the meetings he runs, work through stalemates by analyzing problems from a different perspective. Haley will say: "Let's look at this issue from the 100,000 foot level." Perhaps it may be worth a few paragraphs to take a look at the ATV process from 100,000 feet. From this altitude it is possible to see what is happening with HDTV in Japan and Europe, to examine the emerging global communications infrastructure, and observe developments in digital television across the entire landscape.

What one immediately notices from this level is the difficult path that lies between the GA proposal and successful implementation of the DATV standard:

- Very high start up costs that must be supported by a broadcast industry that faces many forms of new competition and flat or declining revenues.
- Very high initial purchase costs for DATV receivers combined with limited access to programming while broadcasters decide if they will support the DATV standard and build the required transmission infrastructure.

- A variety of new competitors that will employ digital technology (MPEG 2) to offer enhanced programming services--programming on demand, interactivity and advanced telecommunications services--to the consumer.
- A business and institutional community that is willing to invest in new technologies to build the National Information Infrastructure and use it to improve productivity, the delivery of services, and life long education.
- A glaring lack of features in the DATV standard to allow broadcasters to compete with other entertainment and information providers. These include an interactive response mechanism, demand based services, and a guaranteed delivery infrastructure for highly detailed visual information.
- Most obvious from this perspective are the incompatibilities of the system design with the emerging Global Information Infrastructure.

It is hard to reconcile the fact that the Grand Alliance and the ACATS process have left so much on the table for other industries to take advantage of. From 100,000 feet it is obvious that the next advance in visual communications is the addition of navigation, choice, interactivity and collaboration. One must question why this vision is absent from the ATV process?

Section 2 - Specific Comments About the Interoperability Review Panel Draft Report

Regarding "Assessment of the GA Proposal vs. PS/WP4 Recommendations"

Item 3. Transmission of the signal in progressive scan format - this is an absolutely essential requirement of the system. Imagery must be prepared for the lowest common denominator of the system. An interlaced transmission format will force program producers to limit the resolution of the content to this lowest common denominator. Progressive transmission sets a higher performance standard-- a level of performance required by many stakeholder communities, essential for most NII applications, and the long term *target* established by the Grand Alliance, ATSC and ACATS Technical Subgroup.

Item 5. Viewer transparent channel re-allocation. The minimum acceptable level of performance for the DATV system should be defined from the outset. It would be highly desirable for this performance level to match the resolution of existing NTSC receivers. I will provide more detail in the final section of this submission.

Item 6. Ability to implement lower performance low-cost ATV receivers. This should be the *initial* goal of the system to stimulate demand and help establish the service. America cannot wait 15 years for an affordable replacement for NTSC. If the television industry does not respond to this need, it is highly likely that other industries will provide the commercial and consumer interfaces to the NII, placing the success of the DATV standard in jeopardy.

Item 10. Compatibility to relevant international standards... It is inconceivable that a DATV receiver would not support MPEG II. On the other hand it would be highly restrictive to limit the system architecture to our current vision of digital encoding. The receiver should be designed to be extensible to new standards and delivery infrastructures with both higher and lower bandwidths.

New Criteria

Item 12. Compressed domain switching and insertions in data stream. This is a critical feature of the system and the specifications must be resolved so that this feature can be incorporated in the system for testing.

Item 13. Overlay plane. An overlay plane in the receiver is an essential requirement for the stated objectives (station ID and alert messages), and for a variety of system features that have been given little attention. An overlay plane will be invaluable for the insertion of commercial tags localized to the address of the receiver; for the insertion of text for closed captioning and second language captions; for interactive entertainment and educational programs; and for the synthesis in the receiver of appropriate displays from ancillary data. Local synthesis will also enhanced the capability of video printers connected to receiver--a feature just announced for the Time-Warner Full Service Network in Orlando. It is not necessary to specify the standard for a receiver overlay plane--only how to encapsulate the data. Receiver manufacturers can decide what level of graphics performance to include in the decoder. A simple receiver might offer limited fonts and colors, while a more sophisticated receiver could display virtually any text, graphic or document using a more sophisticated graphics engine and a document interchange standard (e.g. the Adobe Acrobat Portable Document Format).

Regarding "Context (for ATV --- NII considerations)," I find a profound lack of reality in this section.

"ATV is happening: digital HDTV, digital SDTV..." This is wishful thinking. There is not a single digital HDTV system on the air anywhere in the world; analog HDTV systems have been a commercial failure. The technology for Digital HDTV has been demonstrated, but a successful economic model has yet to emerge.

What IS starting to happen is Digital Television. Products exist and are being used today at the level of QuickTime and Video for Windows on PC's. By the end of this year there will be more than 4 million PC's equipped with a CD - ROM and the necessary software to deliver motion video. Dedicated videoconferencing systems using switched 56 service are available and desktop videoconferencing systems using Ethernet and standard telephone lines are now reaching the market. Digital nonlinear editing systems are being used to edit episodic programming and feature films. Early next year MPEG will be commercialized in Direct Broadcast Satellite and interactive digital cable systems.

"NII is happening: Internet, conferencing radio..." If you are reading this report, chances are it traveled through the Internet. It should be clear from the meetings October 6th and 7th that the NII is happening!

"Desire exists and will increase for universal access (to information services in the public interest); but the market incentives are unclear." Guess whoever wrote this has not had time to watch much TV lately. Seems that TCI and Bell Atlantic have found adequate market incentives to create a $30 billion company to build a piece of the NII. And S.W. Bell felt a 5 billion dollar investment might help Time Warner build out Full Service Networks. It is estimated that this emerging information industry will invest $200 billion dollars on infrastructure within the next five years. A bit risky if there is no market incentive for this investment.

After the TCI/Bell Atlantic announcement stocks in companies that are involved in building components of this digital infrastructure or the production of content took off. Cap Cities was up 41 points for the week while CBS rose 32 3/8. Even Apple stock went up 5 5/8 in spite of reporting a 97% decline in earnings over the same quarter last year. Apparently the market incentives are only unclear to those who would shackle broadcasters with a system that may be obsolete before it can be built...or is that the point?

" There is agreement on the goal of NII compatible consumer products. The discussion is on tactics of how we get there...What design features of ATV would foster earliest access to NII services?" Perhaps I can help with this one. **How about square pixels, progressive scan, a scalable resolution hierarchy with an entry level that everyone can afford, provisions for interactivity and complete compatibility with the wired and wireless NII infrastructure.**

Regarding "Recurring Issues:"

Item 1. MPEG-2 Compatibility. We must be careful not to let the MPEG bandwagon drive us into another closed standard like NTSC and PAL that will limit extensibility for the life of the ATV standard. MPEG is a good starting point, but the system should be designed in a way to encourage rapid evolution in the area of image encoding. Thus the transmission standard should be concerned only with how bits are radiated--modulation specifications and the packaging of the data (Header/descriptors). The FCC could establish a registry for codecs and a process for approving additions to the registry. The system might go on the air with MPEG 2 and the ATV codec with AC leak. The solution to this problem is flexibility in the design of the decoder--an extension of the MPEG toolbox concept. As new encoding and decoding technologies evolve they should expand the toolbox. All previous codecs would be supported while new hardware would add functionality. The consumer and the manufacturer's of the system components would benefit from a built in upgrade path.

Item 2. Interlace and Progressive vs. Progressive-only. I believe it is sufficient to state that several stakeholder communities have found interlace to be completely unacceptable for the presentation of their product. On the other hand, I have never heard an advocate of interlace claim that progressive scan is unacceptable for the presentation of their product--instead they complain about the difficulty of achieving this desirable goal and claim that the *interim* use of interlace is the only practical solution...someday, they too will become true believers in progressive scan.

I believe that the only practical solution for the universal sharing of visual information is the common representation of this information with orthogonal, temporally coherent samples. As with NTSC and PAL, the quality of the imagery can improve as the technology evolves. Electronic image acquisition systems have not yet evolved to take full advantage of any of the proposed progressive scan GA formats. Today these cameras provide little more resolution than can be displayed on a far more affordable proscan 480 or 576 line display. Meanwhile film provides more resolution than can be delivered by the *target* proscan format and it can be delivered at 24 and 30 Hz using progressive scan today. A well designed system will accommodate a variety of image acquisition systems, and allow improvements in electronic acquisition and display technology to be incorporated as they are developed.

Item 3. Multiple Formats, benefit vs. cost. The benefit of multiple formats lies in the ability to match the cost/performance requirements of an application. No single format can handle every requirement economically. Multiple formats have already been acknowledged by the FCC in requiring simulcast during the transition to ATV. The maximum benefit of multiple formats, and interoperability, can be achieved by choosing formats that have appropriate relationships to existing formats such as NTSC and PAL and to each other. This will be discussed in detail in the third section of this submission.

Conversion between the formats proposed by the Grand Alliance is overly complex due to the inclusion of the interlaced format. In addition, a scaling engine will be required in every receiver to deal with the use of both 1.5:1 and 2:1 scaling factors between NTSC and the proposed formats. This is likely to increase the cost and complexity of every receiver.

Interoperation among formats is already a practical reality today. With scaling engines (DVE's) and format converters, images are routinely windowed into other images. A windowing environment naturally lends itself to the use of multiple formats. Continued efforts to fill an entertainment display from edge to edge are already giving way to windowing techniques. This can be observed in many commercials and programs that letterbox the image and place text outside the imagery in the *throw away* area. As the resolution of captured imagery is increased it is much easier to scale the imagery both up and down--NTSC does not scale up well because it removes most of the high frequency detail. Finally, many image processing and compositing programs are now available for personal computers and workstations. These programs are *resolution independent*, thus the same program can be used to create a 320 x 240 pixel movie for CD-ROM release or a 4k by 2k effect for a feature film. Working with multiple image formats may become one of the most intriguing benefits of a digital production system.

Item 4. Square Pixels. Multiple representations of image samples are a significant barrier to interoperability. Square pixels are the common language of digital imagery and the *lingua franca* of the NII.

Item 5. 1080 vs. 960. 960 lines offers the significant advantage of being 2 X the NTSC line rate, making the display of NTSC on a 960 line receiver quite simple--in fact line doubling will remove many of the most objectionable NTSC interlace artifacts. 1080 offers the advantage of a 1.5:1 scaling factor between 480, 720 and 1080--this is beneficial to a hierarchical architecture. Unfortunately, there is no 1080 line equipment currently in existence and the Europeans seem to prefer their own 1152 line HDTV format. There is little support for the 16:9 aspect ratio or the 1080 x 1920 common image format within the motion picture industry, as evidenced by the submission from the American Society of Cinematographers and the presentation by Robert Hummel of Disney Studios. One solution is a wider aspect ratio with 1024 lines, which will be proposed in the third section of this submission.

Item 6. Migration Path. There is no affordable display technology available today to support the target 1080x1920x1:1X60Hz format. Support for the common image format comes primarily from the ATSC. As mentioned above the motion picture industry does not support this format. Europe continues to promote the 1152 x 2048 format due to the 2:1 relationship with 576 line PAL. A workable migration path must be defined when the system is conceived. It cannot be added as an afterthought. This subject will be covered in the next section.

Section 3 - Proposals for a DATV Transmission Standard Compatible with the Emerging National Information Infrastructure

Although *interoperability* with the National Information Infrastructure is not viewed as being critical for the success of the DATV standard by some individuals within the ACATS process, the decision TO develop interoperable DATV formats could have a profound impact on the 21st Century communications infrastructure. The opportunity is at hand for the television industry to play a major role in the development of this infrastructure, or to travel down a different path.

NTSC and PAL stimulated a process that has seen continuous improvements in system performance for forty years...more than fifty if we go back to B&W. Unfortunately many of the improvements in image acquisition and display technology have not passed along to the consumer, due to the limitations of the NTSC and PAL transmission standards. Today's broadcast cameras can produce greater than 500 lines of both vertical and horizontal resolution but all of this information cannot be transmitted.

The *Reference Standard* for video today is the VHS video cassette viewed on a 20" to 27" interlaced display. The delivered resolution of this combination is no more than 300 x 216 image samples, taking the performance of the display and the VCR into account (samples are subtracted to account for overscan). NTSC transmissions approach 360 samples after overscan is subtracted. The basis for this analysis is the maximum number of black to white transitions that can be perceived by the viewer at the nominal viewing distance from the display.

The Grand Alliance proposes to raise the *reference standard* to no more than 1550 x 432 samples based on the lowest common denominator 960x1728x2:1x60Hz format (10% safe title is assumed). Perhaps only 1300 x 432 if a 960 x 1440 transmission format is used. What's more, there is no guarantee that a consumer receiver and recording system would perform at this level. In order to make receivers more affordable the display resolution might be limited to roughly 768 x 432 providing equivalent H & V resolution. Such has been the experience with the Japanese MUSE system--in order to provide a more affordable entry level display ($8,000), a 27 inch receiver is now available that displays less than half of the transmitted resolution.

This is probably a worst case scenario, but the worst case is typically the one which content developers must produce for. I spend a great deal of time training media producers how to use computer systems to create content for video program distribution. Using square pixel NTSC (640 x 480) as the starting point I explain that they cannot place any critical information near the edges of the screen because of overscan, thus the useful aperture is reduced to 576 x 432. Then I explain that all lines must be drawn in increments of two pixels to prevent annoying flicker on an interlaced display. Actually vertical lines can be in single pixel increments, but most graphics look distorted if the line weights are different for the vertical and horizontal elements of a graphic. Then I tell them about illegal colors.

At the Interoperability Review Board meetings the concept of a NII reference aperture was suggested and discussed. This concept is highly desirable for the publishers of any kind of information and critical to the success of the NII. Media must be produced in a way in which it can readily be consumed--in the case of educational applications of the NII it should be available to everyone.

As an experienced producer of media content, I have observed that the following criteria are critical to the success of a media delivery system:

A. Knowledge of the size (in pixels) and aspect ratio of the minimum viewable display area.

B. The maximum level of detail (resolution) that can be delivered without the introduction of artifacts. Note that the word *objectionable* does not belong in this discussion. The elimination of artifacts is the only standard by which such an important initiative as the NII can be measured. One user's *acceptable* artifacts are anothers' barrier to market acceptance.

C. A few key standards--NII Reference Standards-- are critical to the success of the information infrastructure and will allow for both short and long term content development. Industries may choose to utilize a subset of these reference standards to conform with existing practice--e.g. different aspect ratios and levels of information content.

D. While more difficult to achieve, international standardization is highly desirable. The ability to release media content in one format for international distribution significantly enhances the value of the media and the distribution infrastructure.

At the meeting it was suggested that 720 x 1280 should be the minimum NII reference. While I strongly support the concept of one or more NII reference standards, it is impractical to place the minimum specification at a level that will clearly be out of the reach of many Americans for perhaps a decade or more. Because of this I began to explore the issues of image formats and compatibility with the NII from a different perspective...the view from 100,000 feet.

From this perspective it is immediately obvious that the minimum NII reference must be based on the display capability of the millions of NTSC receivers in use today, and that a more capable NII reference should be established as a primary objective of the ATV process. Extending this logic a step further, the ATV "target" system would represent a third NII reference level. Thus there would be two reference apertures for media producers to exploit immediately and the third would be defined from the outset. This third level would be attainable immediately for the production of many kinds of media content, thus it would have significant value as a mastering and archival format.

After examining all of the requirements to which I have been exposed during several years of involvement with ATV and the NII, a new approach to these problems has emerged. I believe that the following criteria are fundamental to the establishment of NII reference standards and the success of DATV:

1. Square pixels and progressive scanning provide a common language for all types of information and entertainment that will be carried by the NII. These are an essential requirements for an interoperable DATV standard, whether it is delivered by terrestrial broadcast, cable, the telcos or packaged media.

2. There will be many venues of entertainment and information in a digital world. No single transmission format, such as NTSC, can meet the demands of all requirements. Likewise, no single display format can adapt to the diverse requirements for: passive and interactive entertainment; interactive navigation of media servers through the NII; local and distance collaboration using the NII; lifelong education and training; the production of media; and the consumption of information and entertainment by large audiences--business presentations, classroom education, electronic theaters, sports bars, and stadiums.

3. There is no technical reason that information and entertainment programs produced to NII reference standards cannot be viewed on all of the displays that might exist to meet the requirements described in item 2. This implies that scalability is an essential requirement of the DATV system and that some displays may only provide a "window" into the content that can be viewed on a more expensive display with a larger *desktop* or *canvas*.

4. During the transition to DATV, existing 480 line 4:3 aspect ratio program sources will be a critical part of the programming mix. It is highly desirable that DATV receivers interoperate with NTSC transmissions and the archives of videotaped material currently owned by industry, government and individuals. It is also highly desirable that a low cost interface to the NII be developed for the millions of existing NTSC receivers.

5. It is critical that NII reference standards be created as "lowest common denominators" for the producers of media. It is likely that this will be a family of standards to deal with the NII applications described in item 2. For example, the following reference standards might exist:
   Level 1 - information must be viewable at 576 x 432 resolution properly filtered for an interlaced NTSC receiver. This would guarantee no loss of information due to overscan or impairments due to interlace artifacts. It would also enable interoperability with the low resolution displays of a new generation of portable information devices being developed by the computer and telecommunications industries.
   Level 2 - information must be viewable at 1024 x 512 resolution on a proscan display or line doubled interlace display with twice the pixel resolution (2048 x 1024). This would form the baseline for an NII capable wide screen DATV receiver.
   Level 3 - information must be viewable at 2048 x1024 resolution on a proscan display. This would provide a high quality level for the delivery of media and a production and archival format for media that will be delivered at Level 2.

In designing a new digital image architecture, the most important feature is the ability to accommodate the diverse requirements of many applications and industries. There is no way to escape the reality of 480 and 576 line formats with a 4:3 aspect ratio--virtually all existing television archives fall into one of these buckets. There is also no way to escape the reality that the masters for many of these archives are on film, at 4:3, 1.85:1 and

2.40:1 aspect ratios. The architecture should accommodate the transmission of all of these formats without the need for cropping with pan and scan. This suggests the creation of an appropriate reference display with apertures for common image formats--in the computer industry this concept is called "windows."

Windowing or letterboxing on CRT's tends to be viewed as undesirable by many people in the television industry. However, the limitations of CRT display technology should not be the major criteria in designing a system that should last for the next fifty years. Rather, we should acknowledge the probability that display technology will evolve in the direction of projection and flat panels with virtually any aspect ratio. It is therefore far more logical to develop an architecture that accommodates all applications and image formats, takes full advantage of the underlying digital technology, and is optimized for the human observer.

A reference aperture of 2:1 offers many benefits to such an architectural approach, matching up with digital processing components and the normal field of view of the human observer. It also provides a good compromise for the apertures of most existing image archives. The wider formats throw away a small portion of the top and bottom of the screen, while the narrower formats throw away the sides. These throw away areas can be used for the display of information such as the time, channel, navigational tools, and previews of other channels.

It is assumed that all pixels will be displayed since there is no need for overscanning in a digital system. Only the displayed aperture need be encoded and transmitted, freeing up bits for improved image quality.

From these requirements I have created two NII/ATV reference formats with apertures for the most common sources of imagery. The Level 1 reference aperture is a subset of Level 2; it could also be delivered to NTSC displays using an external digital decoder. These formats are illustrated in diagrams which accompany this submission.

A number of interesting compromises are made possible through the adoption of these reference formats. Assuming no scaling of the imagery, at 480 lines, NTSC would be 32 lines short of filling the vertical dimensions of the 1024 x 512 reference display, while PAL would require an 11% crop from 576 to 512 lines. This is very close to the 10% overscan that most program producers assume for safe action and safe title. With the addition of a scaling engine many choices for filling the display are available to the consumer.

Perhaps the most interesting aspect of this approach is that a simple migration path to the 2048 x 1024 proscan target format is built in, and this path allows for the use of interlaced displays. Let's assume that the transmission formats permit apertures up to 1024 x 512 and 2048 x 1024 at 24, 30 and 60 Hz, progressively scanned. Only 2048 x 1024 x 60 is impractical for terrestrial transmission at this time, an academic problem considering the fact that a display of this resolution is only practical (affordable) for theaters, sports bars, the military and a few professional applications.

However, a 2048 x 1024 interlaced display is achievable with today's technology. A simple low pass filter will allow this display to handle the 2048 x 1024 proscan transmissions at 24 and 30 Hz. The best part is that such a receiver can also display the 1024 x 512 formats using progressive scan. Such a receiver could carry the NII seal of approval for the 1024 x 512 proscan reference aperture.

"""IF""" a two level spatial resolution pyramid is included in the transmission system, a 1024 x 512 proscan receiver will require only one quarter of the memory (and related processing) of the 2048 x 1024 receiver--a significant cost savings. This receiver would also conform to the 1024 x 512 proscan NII reference aperture.

An interlaced version of the 1024 x 512 receiver could be sold for entertainment applications, though it would not conform to the 1024 x 512 NII reference aperture. However it would comply with the less demanding NII reference aperture of 576 x 432 properly filtered for interlaced display.

In closing, I suggest that the Interoperability Review Panel take another look at their draft report and the opportunities that are being bypassed by the current approach to DATV. Consensus is never achieved without cost and the compromise of entrenched positions. In this case the long term benefits of collaboration on an ATV standard are far greater than the short term costs of compromise. Please take the time to resolve these issues and set a course for the Grand Alliance, and the future of television that serves the most important stakeholder community in this decision...yourself, your neighbors and the billions of individuals who reside in our global village.

Craig J. Birkmaier
PCUBED

REFERENCE TRANSMISSION APERTURE 2048 x 1024 - VIEWABLE PIXELS

Square Pixel- Progressive Scan - 2 MPel Memory

	H x V Pixels	Aspect Ratio	16 x 16 Pixel Macroblocks	Application(s)/Notes
NII Reference Level 3	2048 x 1024	2:1	128 x 64	Entertainment Education Media Publishing Videoconferencing
Programming Apertures Within NII Reference Level 3				
Cinemascope	2048 x 864	2.40:1	128 x 54	Cinemascope Release
Theateric & Television Film	1856 x 1024	1.85:1	116 x 64	Theatric & Television Film Release
1125/60 & 1250/50	1824 x 1024	16:9	114 x 64	Upconverted 1125/60 & 1250/50 De-interlace; spatial resample 1250/50
Two Page Print Display	1584 X 1024	11:17	99 x 64	Two Page Display @ 93 dpi Electronic Pre-Press Education Media Publishing
PhotoCD	1536 X 1024	1.5:1	96 x 64	PhotoCD Base image plus 1st enhancement residual
Workstation Display	1280 x 1024	5:4	80 x 64	Workstation Display
High Resolution 4:3	1280 x 960	4:3	80 x 60	4:3 Program Masters & High Resolution Distribution

REFERENCE TRANSMISSION APERTURE 1024 x 512 - VIEWABLE PIXELS

Square Pixel- Progressive Scan - .5 MPel Memory

	H x V Pixels	Aspect Ratio	16 x 16 Pixel Macroblocks	Application(s)/Notes
NII Reference Level 2	1024 x 512	2:1	64 x 32	Entertainment Education Media Publishing Videoconferencing
High resolution PC display Superset of NII Level 2	1024 x 768	4:3	64 x 48	High Res PC Display Education Media Production Videoconferencing
Programming Apertures Within NII Reference Level 2				
Cinemascope	1024 x 432	2.40:1	64 x 27	Cinemascope
Theatric & Television Films	928 x 512	1.85:1	58 x 32	Theatric & Television Films
1125/60 & 1250/50	912 x 512	16:9	57 x 32	Downconverted 1125/60 & 1250/50 De-interlace & spatial resample
PhotoCD & PAL	768 X 512	1.5:1	48 x 32	PhotoCD & PAL PhotoCD base image; full horizontal PAL aperture with an 11% vertical crop
Standard Resolution 4:3	640 x 480	4:3	40 x 30	Basic PC Display Full NTSC Aperture
NII Reference Level 1	576 x 432	4:3	36 x 27	NTSC Viewable Pixels 10% crop for overscan; filter to prevent flicker on NTSC receivers

October 15, 1993

To:

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Robert Sanderson
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From: Wayne Bretl, Zenith
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Attached is a note on fixing a "problem" with interlaced reception of progressive material raised at the interoperability meetings last week. I am also distributing this to the Grand Alliance Format Specialists Group and by e-mail to the hierarchy group.

October 15, 1993

Avoidance of Backwards Compatibility Problems in Interlaced Displays for the Grand Alliance System

Wayne Bretl Zenith Electronics

Some of the more vehement supporters of progressive scan have suggested that if the G.A. system includes an interlaced mode of transmission and receivers with interlaced display, it will be impossible to introduce 1080P service with full vertical resolution, since that would cause intolerable flicker on existing interlaced displays. They argue that even the initial 24 and 30 Hz film modes will have to be transmitted with reduced vertical resolution to accommodate the receivers with interlaced displays, and therefore the target progressive system will never be achieved.

On the other hand, some fervent supporters of interlace staunchly hold the position that there is nothing wrong with interlace, that you would never try to increase the vertical detail significantly beyond what is achieved with present interlaced cameras, that interlace will be sufficient for all reasonable applications, etc., etc.

Both these arguments are supported by some facts, but the opposing camps are attempting to stretch what is true on each side to exclude the other's position.

The facts are that for many pictures, the level of vertical detail achieved with interlace is adequate, without excessive artifacts. The facts also are that for many other pictures, the achievement of the full detail possible with 1080 progressive would cause intolerable flicker on a 1080 interlaced display.

Fortunately, the G.A. system allows simple means of preventing excessive aliasing in interlaced displays both in the initial modes of transmission and in the target 1080P mode.

There are four cases of 1080 interlaced display to consider:

1) 720 progressive transmission (any frame rate)

There will be some interlace artifacts produced in a 1080I display which is converted from a 720P transmission. Their severity will be reduced by the fact that the 720P source has about the same vertical resolution that is appropriate for display in 1080I. (1080I has a lower "Kell factor" than

720P, but a higher line count to make up for it.) Therefore, this case is not a particular problem.

2) 1080 interlaced /60 fields per second transmission

This is the native format for the 1080I display, and as Sony et. al. correctly state, the 1080 interlaced camera will be adjusted to give pleasing pictures without excessive artifacts. That this involves a trade-off of resolution and artifacts should be undisputed; that is why the ultimate goal is 1080P. Therefore, this case is not a problem.

3)1080 progressive transmission at 24 or 30 frames per second

Here a problem occurs, if the vertical detail is boosted to a level which takes full advantage of 1080-line progressive displays, e.g., computer graphics which contain single-line-height horizontal lines, or natural scenes which are captured by a non-line-pairing pickup device (flying spot telecine). The solution is to include a filter in the interlaced receiver for vertical depeaking (TV terminology) or anti-aliasing (computer terminology), which is activated only upon the reception of progressive transmissions, and operates on the complete frame of video before outputting the picture in interlaced fields to the display. This filter reduces the high frequencies which cause interlace artifacts. The result is that details which exist on only one line of the progressive source (and therefore only one field of the interlaced display) are vertically smeared so as to appear (at least partially) in both fields. The circuitry to accomplish this already exists in the G.A. receiver, to convert 720P to the interlaced display. Some flicker may remain after filtering; this is a normal trade-off for resolution in an interlaced display. The usable resolution will be similar to that produced in 720P displays, which also must filter to convert from 1080P transmissions.

4) The target 1080 progressive transmission at 60 frames per second

In this case, the transmission will be by means of a main data stream (to accommodate backwards compatibility) and an enhancement data stream to carry the additional data required to reconstruct the 1080P 60 frames per second picture. The main channel can be in any of the initial G.A. formats. It can then be treated by the interlaced receiver as for the corresponding case above. The particular cases are handled as follows.

4a) Main transmission at 1080I 60 fields per second

Part of generating the main signal should include filtering it to make it suitable for interlace, because it is taking the role of an interlaced camera for existing receivers (section 2 above). The residual to be transmitted in the enhancement channel is the difference between this interlace-appropriate main image and the 1080P image.

4b) Main transmission at 1080P/24 or 30 frames per second

The main channel can be transmitted in full vertical resolution, because in the interlaced receiver it will be appropriately treated by the anti-aliasing/depeaking filter (section 3 above). The enhancement channel then carries temporal enhancement only.

4c) Main transmission at 720P/60 frames per second

The 720P main channel can be derived at the source as appropriate for 720P receivers, and the 1080I displays will handle it normally (section 1 above). The enhancement data is then strictly a spatial enhancement.

Conclusion

Simple vertical filtering in the interlaced receiver will allow full interoperability of the G.A. system with various sources and displays, and will in no way penalize or delay the use of the full capabilities of any of the formats. 1080 progressive displays (for those who can afford them) will display the maximum quality attainable in all formats from the beginning. Availability of services will be enhanced by a wide choice of interoperable displays for the end user.

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October 15, 1993

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Mr. Robert L. Sanderson, Chair
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on Interoperability
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Dear Bob:

I should like to express my strong support for the long-term technical, user, and producer benefits of FCC adoption of HDTV broadcast transmission standards accommodating only progressively scanned video images with square pixel placement. I believe these benefits will be significant within the broadcast and entertainment industry, and further enhance the growth and productivity of our evolving national information infrastructure (NII). I further believe that U.S. adoption of such rules and regulations will motivate accelerated international adoption of similar standards promoting interoperability, significantly enhancing the productivity and performance of our simultaneously emerging international information infrastructure.

I believe that economic and other arguments based on the greater near-term availability of more interlaced cameras and displays at lower cost than progressive ones should be discounted. The point is that an exclusive progressive-scan transmission standard is completely consistent with use of interlaced cameras and/or displays in the early days of HDTV. Moreover, the incremental costs of any early interlaced HDTV receivers should not increase observably as a result of this progressive-scan-transmission-only policy. I believe the improved quality of digital HDTV will be so dramatic relative to what people are accustomed to that any slight differences in reception quality as a result of this policy issue should be negligible. I believe that it would be far